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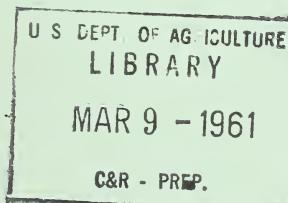
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A³ A method of
CONTINUOUS FOREST INVENTORY
For Management

by

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STATE & PRIVATE FORESTRY



✓ ✓
EASTERN REGION — FOREST SERVICE

U. S. Dept. of Agriculture

UPPER DARBY, PA.

1960

UNITED STATES
DEPARTMENT OF AGRICULTURE
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Preface

A well-managed forest should have high-quality, healthy trees of desirable species, at good stocking levels, in an orderly arrangement of sizes growing at an optimum rate. To attain this condition it is necessary to determine at frequent intervals the effect of applied stand treatments or other disturbances so that timely adjustments can be made to reach interim and final objectives.

There are a great many methods for accomplishing initial and periodic collection of basic data. The methods developed in American and European forestry vary from simple techniques to extremely complex processes. Each method undoubtedly has its advantages and disadvantages, depending upon the ultimate purpose one intends to accomplish. Therefore, it is important that the manager of a forest property resolve the objective or purpose which the data is to serve.

One of the purposes of repetitious collection and analysis of detailed inventory information is to provide a basis for developing forest management plans, especially for large industrial holdings. This procedure is called Continuous Forest Inventory (CFI) and has evolved from many ideas, methods, and analyses during the past 100 years.

Because of its widespread application throughout the United States and Canada, variations will be found within its general structure. American business methods have introduced high-speed data processing machines in order to develop analytical reports from data collected on a single unit (individual tree) basis.

The principal characteristics of this system are:

1. Small, permanent sample-plots scattered over the entire forest.
2. On each plot, individual identification marked on every living tree above a selected minimum diameter. Culls are included.
3. For each identified tree, a detailed record tallied directly into a data processing machine card.
4. Remeasurements of trees on these plots made at intervals of 5 years or less.
5. Harvesting or stand-improvement operations performed on the sample-plots in the same manner as on the rest of the forest.
6. Full use of data processing machine calculation and primary report writing.

7. A business-like approach, including a detailed work flow plan, field and office work seasonally scheduled, thorough training, and effective field and office supervision.
8. Machine statistical analysis of records.

With minor differences within the method, about 50 managers of over 20 million acres of forest land in the United States had established more than 40 thousand CFI plots by early 1959. Similar CFI programs exist in Canada. More than 15 thousand plots on nearly 4 million acres have been remeasured. Analysis of "difference" reports have resulted in major changes in forest management policy in a few cases — minor changes in others. To date, more than 1,000 plots have been remeasured a second time.

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A Method of
CONTINUOUS FOREST INVENTORY
For Management Purposes

What Is Continuous Forest Inventory?

In any business enterprise, a continuous inventory consists of an up-to-date, detailed account of stock on hand. Actually it is a system of periodic reinventories with a short interval between the recounts. Such information is used by a manager to help him exercise some measure of control over the details which he can manipulate to make his business a successful venture.

To be able to control the value-wise development of a tract of timber, a forest manager needs such periodic, up-to-date knowledge of the kind, size, number, and condition of the trees that make up his stock—the timber resource in his woods. Continuous Forest Inventory (CFI) is a special type of cruising with records kept in the required detail and repeated at short intervals for the purpose of obtaining data to be used to guide (or control) forest management.

Relationship of CFI to Cruising

CFI does not replace the cruising and mapping which is necessary in the course of making annual sales of marketable timber. There are never enough CFI plots in a small "logging chance" to yield sufficient local information for timber sales purposes. Factors that affect growth of value of a forest as a whole are considerably more numerous than those required to calculate present, graded-volume of marketable trees. A much greater amount of effort in planning, training, and supervising is required to meet the objectives of a continuous forest inventory than is necessary to meet objectives for many of the other purposes for which cruising is done.

Remeasurement Period

In the grocery business where many items are "turned-over" daily, an inventory may be required to show the record of stock at the end of each day. In other businesses, a week, month, year, or longer period may be the interval most effectively used. Forest management is concerned with trees which have a yearly growth cycle and with units of forest area (working circles) on which repeated cuts (cutting cycles) generally occur at intervals of 10 years or longer. On large forest tracts the usual CFI remeasurement interval is 3 to 5 years. At this frequency, several remeasurements are made during the period of one cutting cycle and trends in forest development become apparent in time for management practices to be intelligently modified to maintain progress towards objectives.

The Basic Unit

In the forest the basic unit is the tree. On a 100,000-acre property there may be 5 million trees over the minimum size for tally. To maintain a periodic inventory of all trees, with several items of information listed per tree, would entail a prohibitive cost. To measure cause and effect, a small sample (if representative) would be adequate and economically feasible.

CFI in Europe

In Europe (Switzerland and Germany) the idea of CFI occurred to foresters 100 years ago. At that time they decided their best approach

would be to periodically make a 100% inventory of a sample block selected to be representative of a large tract. By treating the whole area alike, the sample block would indicate the likely effect of the silvicultural treatments when applied to the much larger area.

CFI in North America

Because CFI involves great detail and must be completed and the results analyzed in a short period of time, it was impractical to attempt CFI on large tracts in North America until new field techniques and machine data processing had reached a satisfactory stage of development.

In the last quarter century, analysis of the variance of sample records has resulted in development of controllable sampling techniques. Added to this, development of data processing equipment to the point where data can be conveniently listed in the woods directly on punch cards has made possible practical application of the principle of CFI. At the present time, American forest industry uses scattered permanent sample plots and complete machine processing to obtain a myriad of analytical reports.

Time for Field Work

The natural accounting period in a forest is one year, one cycle through the seasons. Losses occur from many sources throughout the year. In addition to the trees removed in harvest, losses include trees destroyed by severe weather, insects, diseases, forest fires, and "shading-out" by competing trees. The best time of year to make a management check is after the growing season and before cold and snow have set in to alter dimensions or to hide butt defects. Generally, CFI field work is carried out each fall in a rotation system which reinventories each part of the forest at intervals of not more than 5 years.

Plot Establishment and Remeasurement

On tracts up to 100,000 acres (350 plots) usually all the plots are established in one season and subsequently are remeasured in a single season at intervals of 3 to 5 years. For very large tracts the total number of plots is sometimes divided into 3 to 5 nearly equal groups convenient for establishment in as many successive years. Remeasurement is then made at 3 to 5 year intervals on a rotation basis.

When additional land is acquired, plots are added on the new property in the same manner as on the rest of the forest. Plots on land released from ownership are dropped from the program.

Should statistical analyses indicate that it is desirable to bolster accuracy in some particular area, more plots may be added intermingled among the original set.

Sample Plots

On tracts of 100 acres or less, one plot per acre may be used. On very large tracts the number of plots is usually about one plot for each 300 to 400 acres. A formula that calculates the approximate number of plots used in many cases of record is:

$$\text{Number of plots} = 100 + (0.0025 \times \text{acres in tract}).$$

To explore the usefulness of CFI, some foresters have cut this figure in half.

On the other hand, some forest schools and experimental forests have doubled it in order to obtain finer detail in the forest structure.

In most cases plots have been systematically spaced on the corners of a grid placed over a map of the entire forest. Occasionally locations may be at random, or at random within blocks. One or more plots may be set up at each station.

Plots are generally circular and range in size from 1/10, 1/7, 1/5, or 1/4 acre depending upon the size of timber to be grown. Each plot center is permanently marked. Each measured tree is marked at the point where diameter breast-high (dbh) is measured and below this point with an assigned tree number. The marking is usually done with a good quality, outside, white-lead house paint from a small "gun." Data is entered directly into punch-cards.

Plot Record

On a *plot master card* (usually IBM Port-A-Punch and formerly IBM Mark-Sense) the plot is described as to topography, forest cover, and timber-stand condition. Over the years, there is a continual change in the forest with respect to species (cover-type), general size of trees, and density of stocking. Plot description is recorded at each remeasurement to determine this change. At the time of each measurement, the acres in the different forest condition classes (type-size-density) are estimated from plot count.

Tree Record

On each plot an individual *tree detail card* is made out for each living tree (usually trees 5.0 inches dbh and larger, including culls). Each tree is carefully measured with a diameter tape (usually to tenths of inches), and its usable height (sometimes total height) is carefully estimated in feet. Each tree is graded for health, product, and quality. Sometimes, history of damage or the need for special cultural treatment is recorded.

At remeasurement, each tree is checked against its former record. Trees that attain minimum diameter in the interim period between measurements are picked up as ingrowth at each remeasurement time.

Plot Treatment

These are management plots—not research plots—and, therefore, the trees on them are accorded no special privileges in the regular cutting plans. In fact, it is *imperative* that the plots be cut over or otherwise treated just like the rest of the forest.

Calculation of Reports

Field data, already on punch cards, is quickly worked up by machine into many different reports. Statistical analyses are made as part of the regular processing of CFI reports. The statistical reports show percents of standard error and coefficients of variation for desired breakdowns of area and forest-condition-class. Statistical expressions for data in minor breakdowns may be calculated; however, amounts calculated for minor breakdowns are usually statistically weak. Statistical data may be used to change the sample-plot pattern to seek specific limits of accuracy for amounts in a particular informational category. Efforts to control accuracy in cruising are usually confined to volumes and areas of major separations in the data.

What CFI Reports Show

At each measurement, CFI reports show the present forest conditions—areas in various cover types, and the number, size, volume, quality, and

health condition of the trees of various species. Difference reports (developed from tree by tree differences obtained by subtracting from the present measurement corresponding data from the preceding measurement) show in relation to time the changes in cover types, the growth of volume and quality or the loss of it, and the elimination or addition of trees in various categories.

The CFI reports permit the forest manager to eliminate many losses heretofore sustained due to lack of knowledge of forest conditions. The most important of these losses involve (1) natural mortality due to insufficient cutting, and (2) declining quality of the stand through poor (or lack of) silvicultural practices.

Use of CFI Information

Reports from the first measurement in a CFI program are frequently used to write a broad forest management plan. Data from remeasurement reports are used to refine the plan.

With remeasurement every 5 years or less, trends in stand growth resulting from past treatment become apparent. From the analysis of CFI difference reports the forester may develop recommendations with respect to production goals and the silviculture required to reach these goals. These recommendations presented to administrative personnel against the background of current and past CFI reports usually will secure the approval and backing needed to allow forest management to be effectively applied.

CFI data may also be useful in the regular bookkeeping required in the business of forest management and its allied industries.

From a CFI a land owner may learn that the productive capacity of his forest is less than, or more than, adequate for his material requirements. This may guide him in buying or selling land to balance his operations.

CFI on Your Forest or Woodlot

Application of the principles of CFI to an individual property is flexible in many parts of the field and office techniques. Standard plans may be followed, or considerable individuality may be exercised to accommodate particular interests.

The Forest Service of the U. S. Department of Agriculture maintains a staff of technical forestry consultants who are available to assist foresters in the establishment and maintenance of CFI on private or public forest ownerships. For information or assistance, contact the Chief Forester, U. S. Department of Agriculture, Forest Service, South Building, Washington 25, D. C., or your Regional Forester whose address appears below.

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